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Interaction Contents for Reconsidering Visually Disabled Parents

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Abstract

According to the Ministry of Health and Welfare, "Status of Registered Persons with Disabilities", the number of people with disabilities is 2,494,460 as of 2015. The lowest rates of children with disabilities were intellectual disabilities (23%) and mental disorders (33.3%). The highest rates of screening were blindness (97%), heart failure (94.4%), and hearing impairment (92.7%). 65.2% of visually impaired people who have already had a disability at the time of marriage, and the remaining 34.8% can be thought to be the cause of high incidence of disability after marriage.

'SID (Seed in the Dark)' project was designed to recapture the visually impaired parent's desire for attachment and the space difficulties of the blind who want to be a normal parent to their children through a visual impairment of a father with 7-year-old daughter. Using Gear VR(Virtual Reality), the general public was able to feel the surroundings as if they had no vision and focused on the hearing. Especially, We expressed the sound wave visually and added the hilarious game element which grasps the terrain of the maze by sound wave like a 'blind person who perceives the surroundings by sound' and catches up with daughter.

People with disabilities who are far from mental illness often have a form of family with children. The fact that the rate of childbirth is high means that there is relatively little problem in daily life. It is wondered that the rate of blindness among the visually impaired, which accounts for 10% of the total disabled, is the highest at 97%. This is because, in the case of the visually impaired, the obstacle is often caused by aging, accidents, or diseases due to inherited causes rather than the visual disorder. In particular,

However, the fact that there is an obstacle in vision that accounts for 83% of the body's sensory organs causes other difficulties in the nursing process of children who are non-disabled. Parents do not know the face of child when their visual impairment is severe. Parents are extremely anxious about worry that they will be lost or abducted if their children are not by their side. And that the child recognizes the disability of his or her parents other than the other parents easily and takes it as a deficiency. Since visually impaired parents are mentally mature parents with non-disabled people, they may want their children not to feel deprived of their disability. The number of people with visual impairments has been increasing since 2001, and people with

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impairments often become disabled. In addition, there is much research on the problem of nondisabled parents who have children with disabilities, while there is relatively little interest and research on the problem of nondisabled child rearing of parents with disabilities.

Keywords: *Interactive Art, Visual Impairment, Spatial Awareness, Disability Parents, Non-disabled Children, Blind, Improvement of Empathy*

1. Introduction

SID project is designed to express the minds of disabled parents who try to look like ordinary parents to their children through the view of a blind father playing tag with his 7-year-old daughter. As there is no vision, the surroundings are black and nothing is visible. The player moves in sync with the body of the father. Player's own body is painted dark invisible but only feet is marked white for giving weight. This is an expression of the assumption that the non-disabled person does not put much meaning in taking a step forward because they know what is in front of them, while the blind person will feel the weight of every step they take. Considering that the main character of the game is blind with no residual vision, the way perceiving surrounding terrain depends heavily on hearing. However, hearing alone has limitations in identifying the terrain, and the topography the game, which is 80 meters in diameter circular maze, is quite complex, requiring a visual method of identifying the terrain. After much consideration, the visual method is showed that the light travels like a sound wave and when it hits the wall, making it reflective. When a player walks, kicks his feet to the ground, or his daughter walks, the sound of his walking changes into a waveform and the light goes on. Players can identify the terrain by looking at the waveform, but they should also pay attention to this. The difficulty is set high as players can feel the difficulties of being blind. It also wanted to realize the problems that blind parents experience (the fact that parents don't know their children's face, the extreme anxiety of being lost or abducted without one's children) in child-rearing through game.

The only time the player can see her daughter is when she talks to her father. Even the image of the daughter in the moment is a fantasy about the image of the daughter that a man has. This is because blind people estimate other's height through the height of their voice and visualize other's shape with touch. It is programmed the voice smaller when distance far between a daughter and a man, inverse case the voice bigger when distance closer between a daughter and a man to enhance reality. When a daughter is more than a certain distance away from a man, he has no idea where she is because he can't see the sound waves coming from her. The player seems to have fallen into the sea of delusion, and feels a sense of urgency and duty to find his daughter quickly. In addition, a man shows his daughter maximum effort to look like a normal father like any other father within the game. Although the game of tag is almost impossible for a blind person, a man fits his daughter. The man doesn't have a hard look when he plays with her.

The daughter is chosen as a childish 7-years-old who is ignorant of the world and the player is could felt "childish" in conversation with her. It is to dramatically express the man's desire to look like a normal father compared to her childish. The daughter knows her father is blind, but she is ignorant of how it is perceived in society. She rather suggested that her father playfully play tag because he was blind. The daughter leads her father toward the exit of the maze, hiding from her father who tries to catch her and sometimes giving him hints about her position. When a man reaches the exit, she thanked her father for playing and ran home to eating like an innocent child. Ending makes the player feel that he is a valuable parent to his daughter and creates impressions linger in his mind.

2. Purpose

The number of people who are blind has continued to increase since 2001. As of 2015, the nation's population for the blind stood at 252,825 people, larger than other disabled people. In particular, we should be aware that anyone can become blind, as 34.8 percent of people are visually impaired after marriage. People often perceive blind people as unusual looking at them as they pass by. This should be restrained because it makes blind people reluctant to go and makes their children feel unusual of parents when they are with their children. The project tries to reconsider people that blind parents are no different from non-disabled parents and don't have to pay special attention to them. The project aims to apply to all kinds of platforms for many people to know as possible. Although the game uses Gear VR, it could be also experienced with other VR equipment, and it has an interface that can be played with regular PC(Personal Computer) game and Android game. It has prepared a variety of input systems, including HMD(Head Mounted Display)'s touchpad, console joystick, keyboard and virtual joystick pad that can be touched. At the beginning of the game, it recognized the platform and implemented proper input system.

VR is the main platform of the SID project. There are many reasons why VR is chosen as the main platform. The project needs to create empathy with blind parents through certain play. VR can effectively restrict vision in that respect. The player can only see the intended part of the game. This provides a more realistic experience than a two-dimensional limited screen. VR also gives players a stronger presence as the main character in the game. This helps the user to focus on the storytelling. It allows the players to enter the story outside the screen. Through these actions, the focus of the user's attention leads to an exploratory phase from the perspective of the blind. Players naturally adjust to their role as the main character in the game with time to adjust to the VR world through tutorials at the beginning of the game. All of the processes through VR allow users to naturally lead the story from the perspective of blind parents. This creats empathy realistically and effectively which is the purpose of the project.

3. Work Flow

3.1 Platform & Input

This project supports a number of platforms. Although VR mostly used Gear VR, which is Mobile VR, it also has no problem with compatibility with Windows VR at all. When using Gear VR, users can use input touchpad on the right side of HMD or use hand controller for Gear VR. Mobile and Windows support Bluetooth, so users can connect joystick. This can be enjoyed not only VR, but also PC and Mobile. When using a PC, the keyboard is used as the basic input and joystick is also available. Virtual joystick pads are created, just like the right part of Figure 1, so you can touch your fingers to control the movement and view of the character on mobile platforms such as Android and IOS(iPhone OS).

The player does not need to know how to use each input in advance. This is because the game's early intro section teaches a tutorial on how to operate the game by playing with the daughter. User first mission is to look at daughter who says "Daddy. Daddy! I'm here". At this point, the player learns how to rotate the view. Then the daughter becomes a tagger and chases her father. The player will become familiar with how to walk and run. The program automatically recognizes which input device is currently connected to the device and provides operation help corresponding to the recognized input device. This help continues until the Player has tried all the functions. Therefore, the player will use at least on operation in intro part.

Figure 1. Main platform gear VR

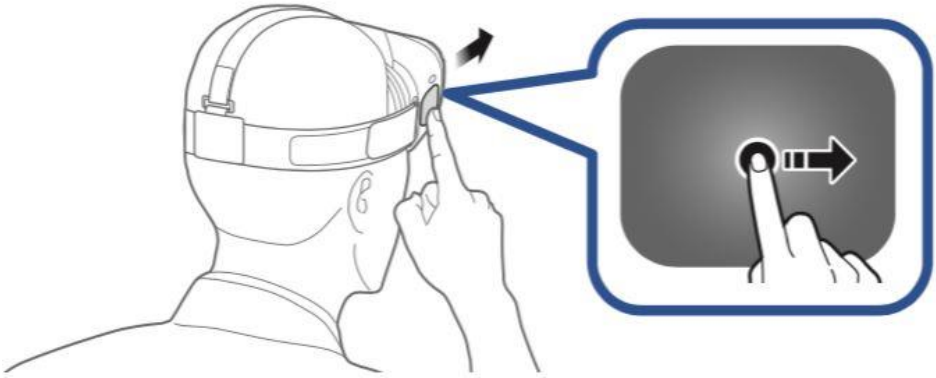

Figure 2. VR controlling

3.2 Terrain(Circular Maze)

The shape of the map adopted a circular maze. The player starts the game in the circular area at the bottom of the maze and follows his daughter to the circular area in the middle of the maze. The daughter runs away from the player and eventually reaches the central circular zone. And the player can see the end of the game when he arrives in the center. There are five traps in the maze. If the player goes into the trap, the daughter comes up to the player and says, “Dad, I’m not there” leading him to the right path. There are several reasons for adopting a circular maze. The first reason is to increase the difficulty of space perception. The second reason is to ensure that there is only on ‘NavMeshAgent’ path that is used in the AI of the daughter in the game. The third reason is that visually represented sound waves are reflected at various angles from a circular maze rather than a flat surface of a square maze.

There is no way to create a circular maze in Unity. The method of materialization maze in this project is as follows. First of all, like the first image in Figure 3, make a 2D maze image with Photoshop. Then separate the image using the Plane in the Maya program. The 3D maze object is created by setting the Thickness to 3m in the separated image’s white area. It is imported to Unity after exporting. The material of the maze is black that matches the color of the light, so the player cannot distinguish whether the wall is present or not.

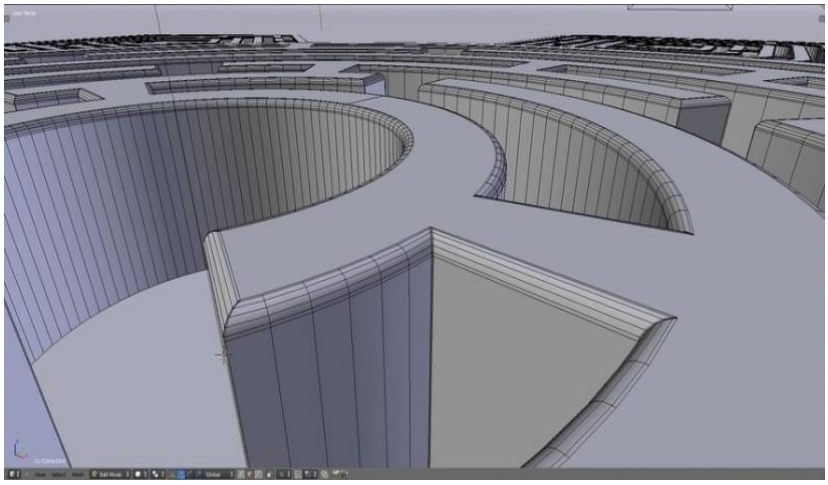

Figure 3. 3D image of circular maze

3.3 Visualized Sound Waves

The differentiator of the game is the visualization of hearing. When a player or daughter moves, the footsteps are visualized by light and spread out. The physical engine adjusts the footsteps to reflect in the proper direction. It allows the player to figure out the terrain. Visualized sound waves randomly occur in six directions (60 degrees intervals) when walking or running. The lights spread in twenty-four directions (14 degrees intervals) when player stamps their right feet.

Sound waves are expressed to show visual beauty as well. The light gradually fades out after one second and completely disappears after up to two seconds. It visualizes the sound becoming smaller as it moves away. The color of the light slowly changes from the starting point to the ending point. The start and end colors are determined by random numbers. The random number used controls the amount of white property that the light should contain as little as possible. It allows light to begin with bright colors and end beautifully in dark colors. The daughter is expressed in white because she is an imaginary figure from her father who is blind. Similarly the sound waves produced by the daughter's footsteps are expressed in white. The player escapes the maze following the white light from his daughter.

The physical implementation of sound waves uses 'Sphere'. After that the AddForce method of the Rigidbody class be used to exert physical force at intervals of 15 degrees. The coordinates of the movement the spheres under the force are recorded in the array of each frame. This is connected by a LineRender, which allows the sphere's trajectory to be represented by light. The friction force was set to zero through the Physical Material and the elasticity to 0.9. It can make to reflect well when the spheres hit the wall. The reason why elasticity is not set to 1 is because the spheres speed up when it is reflected. It is believed to be a bug in the Unity physics engine where floating point error builds up. The spheres in which the force has been exercised moves only on the X and Y axes. In order to appear close to the sound waves at the player's pint of view, a Y-zxis vibrating script is added to the spheres.

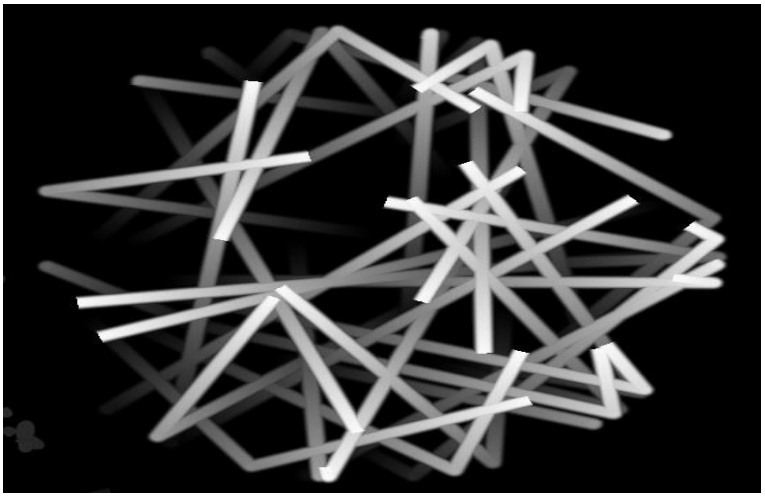

Figure 4. The shape of visualized sound wave

3.4 Footprint

Footprints are also left along with visualized sound waves when the player walks or runs. They are stored in the list and the alpha value is adjusted to fade over time. Walking in place leaves only one footprint to prevent the creation of duplicate objects. Footprints play a big role in escaping the maze. Player can also judge the amount of time that has passed by the fade of footprints.

The development of these functions requires a way to identify the moment the player takes his step. In the early days of game development, the Raycast method was used to do this. The program uses lasers to identify the distance between the ground and the soles of the feet. It is considered to be the moment when the feet touch the ground when the known distance is close to zero. But there is a problem with this method. It has no problem with visualized sound waves, but the timing and location of the footprints are subtly inconsistent. Therefore the Raycast method was not adopted. The player and daughter character's feet were overlaid with Box Collider, which was used as a criterion for OnColisionEnter callbacks. It further elaborated the expression of sound waves and the location of the soles of the feet.

3.5 AI

The way finding function is used with the NavMesh Agent function provided by Unity engine. Doughter NPC(Non-Player Character)'s moving range is specified after turning circular maze and floor object into static object. The NPC automatically heads to the destination when the destination is specified. But the game's key issue is not simple an automatic moving NPC. It is the implementation of artificial intelligence that seems to be playing around by controlling the distance from the player like a mischievous seven-years-old daughter. For that to happen, the distance between the player and the daughter should be calculated not directly but in consideration of the maze. An object called NavMeshPath is used to calculate it. NavMeshAgent plots the paths between the destinations in nodes as a graph. Values between these nodes are added to provide the distance between the player, NPC, and destination. An algorithm for calculating path is used to reduce operation. The algorithm is performed when the player's position has changed by more than 1 meter before. The daughter(NPC) takes different actions depending on the distance. If it is less than 15 meters the daughter runs away at full speed and if it is more than 15 meters she walks away. If she is more than 25 meters away from the player, a resting place is designated so that the player can follow her. The resting place is designated as a node with a value greater than 5.5m calculated by NavMeshPath. The daughter falls while running away

in the scenario which is also a resting place. The distance standard is set at more than 5.5meters because it is the minimum distance for the daughter to run away when the player finds her and approaches her. She stops on her way and goes back to the player when he is more than 40meters away from her or goes into a trap. The daughter goes back to the player saying “Dad, I’m not there.” And when she reaches 4meters from the player, she run away again saying “Catch me dad.” This is a hint for a player who is struggling through difficult maze and an act that her daughter cares about considering her father is blind.

```
public float CalculatePathLength(NavMeshAgent myAgent, Vector3 targetPosition)
{
    NavMeshAgent nav = myAgent;
    NavMeshPath path = new NavMeshPath();
    if (nav.enabled)
        nav.CalculatePath(targetPosition, path);
    float pathLength = 0;
    bool isToDestination = targetPosition == _destination.position;
    posLongPath = _destination.position;
    bool pathNot = true;
    for (int i = 1; i < path.corners.Length; i++)
    {
        float length = Vector3.Distance(path.corners[i-1], path.corners[i]);
        pathLength += length;
        if (isToDestination && pathNot && length >= 5.5f)
        {
            posLongPath = path.corners[i];
            pathNot = false;
        }
    }
    return pathLength;
```

Figure 5. Code of NavMeshPath

3.6 Optimization

SID project is developed by setting Mobile VR as base. The Galaxy S7 selected as a test device has performance that is not bad, but it is poor compared to the latest. Especially it is going to show sluggish phenomenon when VR is carried out with QHD(Quad High Definition) resolution. This is because the device fails to maintain steady 60fps and causes a frame drop. The frame drop prevented the sound waves from being smoothly expressed. To improve this, the program was profiled whit analysis tools provided by Unity engine and performed very well.

First of all, playing game for a long time did not slow down at all. That’s because the part where memory leak occurs when Sprites pile up when objects are being destroyed has been resolved. Second CPU(Central Processing Unit) load slow down phenomenon have improved intensively. It happened most of the time during GC(Garbage Collection). It is fatal especially in mobile. So it was a vital part of the improvement. To solve this problem, the objects frequently instantiated such as sound waves and footprints are not destroyed. Instead it is stored inactive in the caching pool and then used when needed. Dynamically allocated array to record the trajectory of the ball for LineRender also caused frequent GC. It was improved in the same way as well. Thirdly, Rendering was optimized. The elements shown to the player were minimized. The reason why the map was too big and complicated. The maze, daughter, footprints and other objects in the game are kept only the collider, and the Renderer is turned off. They are dynamically turned on when they should be shown to the player. It also eliminated all visual effects such as shadows and reflections because of the blind’s point of view. Through these optimization tasks, game is able to maintain steady 60fps in mobile VR and 300fps in PC

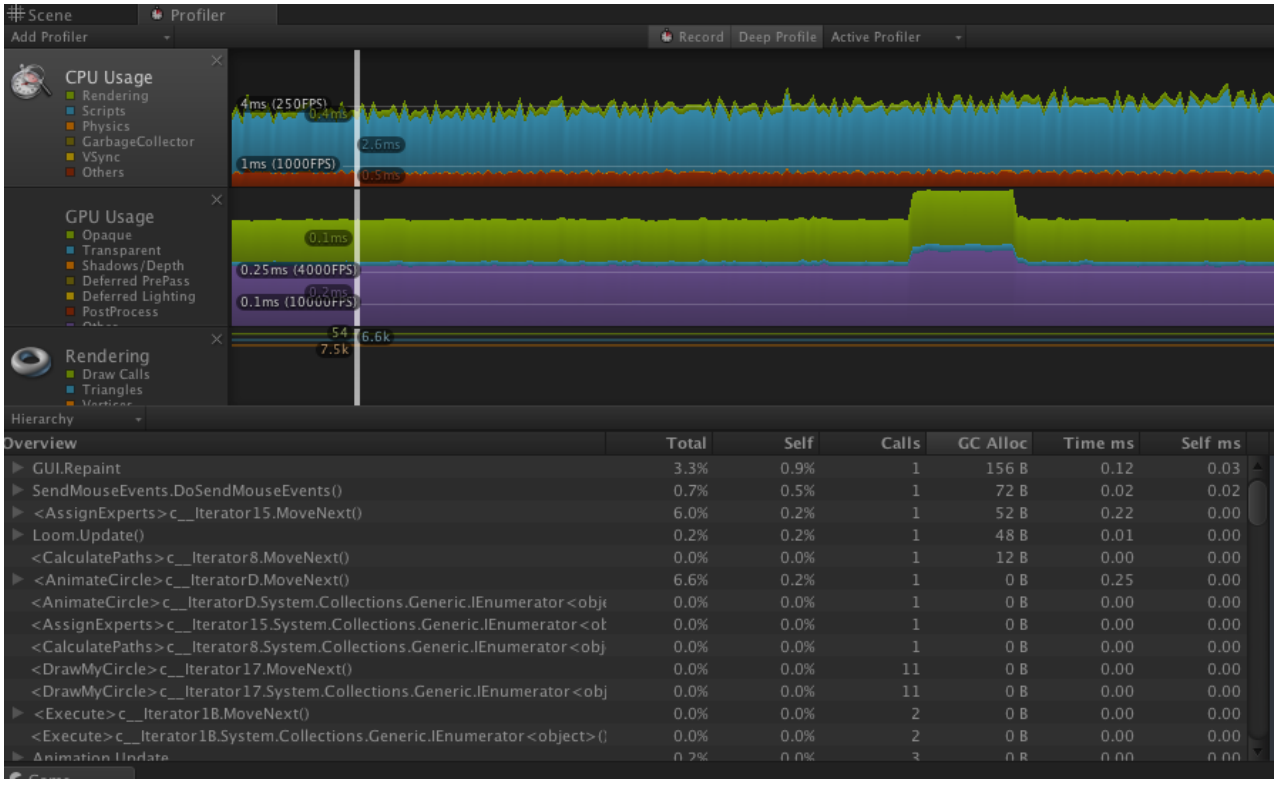

Figure 6. Profiling

4. Conclusion

4.1 Audience Response

Parents' love for their children with disabilities is no difference at all from non-disabled parents at all. But what they can do for their children comes with many obstacles. Disabled people are attracted to people when they go out. In severe cases, some people even give a hateful look at disabled parents, saying "If you have a disability, you shouldn't have children." The more people who give attention to disabled people, the more likely the children of disabled parents are to recognize people's gaze at their parents and be negatively affected. The SID project allows people to experience playing with young daughter from the standpoint of blind people. It attempts to make non-disabled people feel that even parents with disabilities are doing their best to love and nurture their children, and that many of the visual problems that blind people experience.

In other to examine the responses of the project, about 10 students attending IT(Information Technology) and three middle-aged workers in their 40s and 50s were asked to experience the game through VR. Everyone was surprised to see nothing at the beginning of the game even though they knew it was as blind experience game beforehand. Then they learned how to operate though tutorial and then began exploring the maze. Their common reaction is that they find it difficult to draw the terrain completely in their heads despite their concentration to find a way, turn their heads in the direction they hear, feel anxious and frustrated if they don't find their missing daughter, and then feel relieved when she shows up around

In order for a modern society to become a win-win society, empathy among individuals is very important. But to improve empathy, we need to try and practice. Such attempts and exercises may be possible with engineering techniques based on humanistic reflection.

4.2 Improvements

The circular maze used in the SID project complicates the terrain but does not represent the risk that blind people face on the road. They have to be careful even if it's a trivial thing such as car, crosswalk, or bicycle. In the end SID project made people fully empathize with the inconvenience of blind, but not with the danger. Additional devices are needed on the map for deeper empathy.

And while blind people actually use all human five senses, the project focused only on hearing. If VR equipment is developed that can even feel touch, adding touch elements to this project will increase sense of reality.

Acknowledgement

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References

[1] Lee Byung-hee, *A study in blind person's image association methods about others*, Master Thesis, Ulsan univ, Ulsan, Republic of Korea, 2011.

[2] Kim Yeon-jin, *The influence of the parentification as an adolescent of a disabled-parent family on school adjustment : focusing on the moderating effect of social support*, Master Thesis, Sungkyunkwan univ, Seoul, Republic of Korea, 2011.

[3] Lee Hyun-jung, *A study on the blind guide design for barrier-free walking : focusing on a near future Cane type pedestrian guiding equipment*, Master Thesis, Hongik univ, Seoul, Republic of Korea, 2013.

[4] Kim Nam-sook and Kim Min-joo, "An analysis of disability parents' desire for multi-dimensional child care", Journal of Rehabilitation Research, Vol. 13, No.2, pp. 199-223, 2009.
DOI: https://doi.org/10.20971/kcpmd.2001.54.1.61

[5] Heo Jun-gi, "Identification of disability awareness and response of family members towards disability", Korean Society for Disability Studies, Vol. 1, No.1, pp. 5-32, 2016.

[6] Lee Myung-joong, *Developing a smart tactile map for the visually impaired to improve spatial cognition*, Master Thesis, University of Seoul, Seoul, Republic of Korea, 2017.

[7] Lee Jeong-hee, *Study on the current situations and vitalization measures for the ICT application of vision-impaired*, Master Thesis, Incheon national univ, Incheon, Republic of Korea, 2004.

[8] Yang Sea-myung, *Balance difference between visual disability and normal people*, Master Thesis, Keimyung univ, Daegu, Republic of Korea, 2009.

[9] Kim Su-yeon, *A phenomenological method about characteristics of relationship of the disabled*, Master Thesis, Keimyung univ, Daegu, Republic of Korea, 2012.

[10] Park Hyang-kyung, *A narrative inquiry about a family life experienced by mothers of an adult-child with mental disorder*, Ph.D. Thesis, Ewha woman's univ, Seoul, Republic of Korea, 2012.

[11] Choi Seon-ae, *A study on the eyes on the objects of prejudice : with the focuses on my artworks*, Master Thesis, Chung-ang univ, Seoul, Republic of Korea, 2018.

[12] Kim Min-jung, *An exploratory study on mobility and spatial cognition of the visually impaired using grounded theory and mental mapping*, Master Thesis, Sangmyung univ, Seoul, Republic of Korea, 2018.

[13] Lee Yong-man, *A study on the promotion of cultural welfare to improve the quality of life for the disabled*, Master Thesis, Hanil univ, Wanju, Republic of Korea, 2006.

[14] Son Ho-jun, Jeon Hyoung-joon and Kwon Soon-chul, "Study on Distortion and Field of View of Contents in VR HMD", International Journal of Advanced Smart Convergence(IJASC), Vol.6, No.1, pp.18-25, 2017.
DOI: https://doi.org/10.7236/IJASC.2017.6.1.18

[15] Kim Tae-eun, "A Study on Shamanistic Expression Method of Performances Using VR Technology: Body Ownership and Gaze", International Journal of Advanced Smart Convergence(IJASC), Vol.7, No.2, pp.135-142, 2018.
DOI: https://doi.org/10.7236/IJASC.2018.7.2.135